The Thummer™ Mapping Project - ThuMP

Garth Paine
Research Associate, MARCS
Ian Stevenson
University of Western Sydney
SoCA, BD 1.14, Locked Bag 1797
Penrith South DC, 1797. Australia
ga.paine@uws.edu.au
i.stevenson.uws.edu.au

Abstract

This paper outlines research being carried out at the University of Western Sydney to develop mapping strategies for a new and innovative electronic music instrument interface, the Thummer™, being developed by Thumtronics P/L in Western Australia. The research approaches the mapping challenge by developing a model of input variables utilised by expert performers of traditional acoustic instruments, developing a computer model of those relationships as a semi-automated mapping mechanism, allowing the Thummer™ interfaces ten degrees of freedom to be easily mapped to any synthesis algorithm.

Introduction

Musicians continually adapted existing technologies (the turntable, the mixing desk etc) for music making, seeking instruments that express the evolving cultural climate. It is critical that new instruments be developed that facilitate and nurture this expression. Current designs for electronic musical instruments are often based on reductionist models of user interaction and sound synthesis. These models are derived from research in the fields of human computer interaction, industrial design and digital signal processing, lacking musical context, they result in musical instruments that are deficient in subtlety and nuanced expressivity associated with traditional acoustic musical instruments. In addition, current designs often offer ease of use at the expense of the potential to develop virtuosic technique (Chadabe, 2002a, Bahn et al., 2001, Bongers., 2000, Cacone, 2002, Cascone, 2002), and arise from a focus on the application of technologies rather than the demands of the musician. Furthermore, no methodology yet exists for the comparison of interactive music systems across performance, installation, and related contexts (Birnbaum et al., 2005). The area of new interfaces for musical expression is therefore heterogeneous, illustrating a predilection to idiosyncratic approaches and subsequently lacking a theoretical base that equates to the existent norms and contextualizing premise associated with acoustic instrument practice.

In electronic musical instruments, unlike acoustic instruments, the performer's physical gestures are de-coupled from the sound generating mechanism. A crucial step in the development of new musical interfaces is the design of the relationship between the performer's physical gestures and the parameters that control the generation of the instrument's sound (Wessel and Wright, 2002, Cook, 2001). This process is known as control mapping (Roads, 1996, Rowe, 1993, Rovan et al., 1997, Hunt and Kirk, 2000, Hunt et al., 2000, Mulder, 1994, Mulder et al., 1997, Wessel, 1991a, Winkler, 1995, Chadabe, 2002a).

ThuMP

The ThuMP project is an industry partnership between the University of Western Sydney and Thumtronics, the developers of a new and innovative electronic musical interface, the Thummer™, that has more than ten degrees of freedom (DoF), facilitating new and exciting gesture → sonification mappings.

Instrument Overview

The Thummer is attached to a forearm brace, or optionally suspended from a neck strap taking the weight and freeing the hands. The new "Mandurah" prototype is about 18cm tall and weighs only 0.5kg.

Each hand spans a button-field like that of a concertina. The buttons' arrangement is optimized for a layout which is "isomorphic" ("same shape"), meaning that a pair of buttons in a given geometric relationship sound a consistent musical interval (i.e., every musical interval has the "same shape"). As a side-effect of this consistency, the fingering of any given sequence or combination of intervals is the same in all 12 keys.

This property of isomorphism is not limited to the 12-tone scale; it is consistent in any other equally-tempered scale that has a recognizable diatonic scale, such as the 17-tone and 19-tone equally-tempered scale.

Each hand spans a three-octave button-field, so the two hands together span a full six octaves at any given time, allowing notes from the entire six octave range to be sounded together at any given time. Contrast this with the piano, in which each hand spans only about 1.3 octaves so both hands together span only 2.6 octaves of the available 7 at any given moment.

Each finger can press one, two, or three adjacent buttons simultaneously. The keyboard is optimized (through the size, shape, and spacing of its buttons) for playing, with a single fingertip: (a) single notes, (b) perfect fifths, and (c) sus4 or sus2 triads.

Diatonic chords are trivially easy to play, as each is a stack of major and minor thirds resulting in a collection of perfect fifths. Major and minor seventh chords can be played with just two fingers (one on the root and fifth; another on the third and seventh). The dominant and half-diminished sevenths can be played with just three fingers. Extended diatonic chords such as the ninth, eleventh, thirteenth, and even some of the fifteenth chords, can be played with the fingers of a single hand, laid along parallel rows of fifths.

In addition to these keyfield innovations, the instrument has a range of other controls that lay easily under the hands or are a result of performance gestures.

ThuMP provides the opportunity to develop a new electronic musical instrument based on a thorough re-evaluation of the performer's relationship with the performance interface. This new understanding of the subtle mechanisms of feedback and control that allow the development of virtuosic technique, will help to avoid the pitfalls of existing approaches to electronic performance systems. The ThuMP project will also result in the development of gesture mappings for the new interface from the perspective of acoustic music performance, and will produce software mapping tools that seek to partially automate the instrument performance mappings to the employed synthesis engine.

The Research Questions

The research is being conducted in three stages.

1: Discovering Perceptual Foundations

In stage one of the research, we seek to address the gap in current knowledge relating to the number and range of physical control parameters employed by advanced performers and teachers of three main classes of musical instrument: (flute, violin and concertina). A questionnaire survey of performers and instrumental teachers at Conservatorium, Universities and within the profession will be used to obtain a quantitative estimate of accepted control parameters and perceptual timbral parameters under control. This research will be supported by qualitative evidence from cognitive interviews with a selected group of professionals. The results will be evaluated for each class of instruments producing an indication of the number of applied control gestures, and a classification in terms of timbral characteristics. Timbral descriptors will be categorised and compared to the qualitative data for classification. The cognitive interview process will help to overcome the diversity and potential mismatch in the use of common timbral descriptors (Peeters, 2002) by allowing the domain knowledge of both the interviewer and interviewee to be exercised. The cognitive interview approach will also allow detailed probing of the sometimes unique approaches to sound production techniques associated with individual instrumental teaching and performance methods.

Questions

1. How many discrete and multi-modal control parameters are present and applied in a selection of existing experimental interfaces for electronic music performance.
2. How many discrete control parameters do trained musicians and high-level instrumental teachers consciously exercise in normal performance conditions? This question begins to define existing models of musical gesture space with specific reference to timbral control.
3. How do the defined parameters directly relate to audible timbral characteristics? This question re-assesses existing models of timbre space from the performer's perspective (Wessel, 1979a).

2 : Performance And Validation

Stage Two involves two key steps, prototyping and user testing. The prototyping phase includes assessing the Thummer™ prototype's number and range of control parameters using automated data logging techniques. Software for this process will be written in Max/MSP (Zicarelli, 2004). The second aspect of prototyping involves finding a manual best-fit solution for control mapping of simple virtual instruments. User testing of resultant mappings will be conducted with a group of selected performers and from further cognitive interview and focus group session. The outcomes of focus group discussion may lead to new insights into mapping strategies and performance issues and will inform the next step in an iterative development cycle.

Questions

4. What are the useable number and range of control parameters that can be applied si-

multaneously by the performer? This question defines the playable range or gesture space.

5. What control mapping strategies are illustrated in current experimental and mass market interfaces, how can these be organised to provide maximum musical gesture potential, equating to existing models of musical gesture space (Jorda, 2004, Birnbaum et al., 2005).
6. How is "playability" (Young, 2003) defined from the performer's perspective within such a taxonomy of control mapping.

3: Mapping Automation

This final third stage employs a similar methodology. Automated mapping solutions will be implemented, tested and compared to the user testing results from stage two. A final stage of user testing will be assessed through musical performances and final focus group feedback. The performer feedback is an essential element in an iterative mapping development strategy.

Questions

7. Can automated mapping techniques provide improvements in playability and performer satisfaction? This question applies parameter reduction techniques as discussed in (Goudeseune, 2002).
8. Do reductions in control space complexity provide greater ease of use resulting in a system with more application to novice users?

Background

The dilemma as to the mapping of control parameters to musical outcomes has come about due to the removal of the excitation moment from the sounding source in computer-based music. Designers, composers and musicians are left asking what the coupling and affordances of the performance gesture, musical artefact relationship should be. Furthermore, the instrument is distributed between the interface and the computer algorithms that generate the sound, which may in themselves be distributed over networks. Discussion in this area has centred on the concept of interactivity, meaning between the performer and the computer-based instrument (Dean, 2003).

Todd Winkler (Winkler, 1998) proposed four models of interactivity for musical performance:

1. The Conductor Model, ie. a symphony orchestra - controlled centrally.
2. The Chamber Music Model, ie. the string quartet – shared control.
3. The Improvisation Model, ie. a jazz combo, where a defined framework allows frequent passing of control, improvised interjections, interplay and improvised solos passages. The outcome is perceived as musical because it has a shared form and concurs with Winkler's definition of musical understanding above. This behaviour establishes a kind of musical intelligence.
4. The Free Improvisation, where a broad range of often chaotic interchanges, governed by a common musical understanding, encourage a homogenous musical outcome from a vast amalgam of inputs.

A further useful model is that of human conversation (Paine, 2002) which like any good interaction is a "two-way street … two people sharing words and thoughts, both parties engaged. Ideas seem to fly. One thought spontaneously affects the next." (Winkler, 1998). Paine (Paine, 2002) suggests that human conversation illustrates the following characteristics that translate favourably into the distributed interface-computer instrument prevalent in electronic music performance systems. Conversations are:

1. Unique and personal to those individuals engaged in it, it is
2. Unique to that moment of interaction, varying in accordance with the unfolding dialog, but is
3. Maintained within a common understood paradigm (both parties speak the same language, and address the same topic in a manner understood to be conversation).

Within such an interaction the starting point is known by one of the parties, but the terrain of the conversation is not known in advance. It is a process of exchange, of the sharing of ideas. This model has a direct reference to musical improvisation, but with the development of a level of artificial intelligence in the system, the roles of composer, performer, instrument and audience take on a wholesome and innovative new form, moderated by the relationship between interface and performer.

Bongers (Bongers., 2000) points out that many interactive music systems are in fact reactive systems, due to the absence of cognition (the system response is predetermined). He characterises musical interaction in three modes:

1. Performer-System interaction, where a performer is playing an instrument,
2. System-Audience interaction, commonly found at interactive sound installations, and

3. Performer-System-Audience interaction, which describes interactive systems in which both artist and audience interact in real time.

As the above citations illustrate, discussion about electronic music performance interfaces has been largely focused on the nature of distributed control, often referred to as interactivity. Such discussion has been useful in developing the relationship between the performers and the interface, but has not yielded outcomes of substantial value in terms of the relationships between the performer and the sonification mechanisms to which the interface connects. A lack of focus on this specific relationship has led to a very heterogeneous community of researchers.

Early electronic musical instruments exhibited simple one-to-one relationships between control parameters and synthesis parameters. Later commercial systems employed slightly more sophisticated approaches such as linking physical energy input to both loudness and brightness or upper partial content of the resulting sound. While improving the expressive range of electronic instruments these advances left many performers and composers lamenting the lack of complexity previously offered by acoustic instruments. Subsequent research in this area has focussed on identifying timbral characteristics of acoustic instruments from a perceptual basis (Wessel and Wright, 2002) for defining new target control parameters in sound synthesis. This led to attempts to evaluate new performance systems based on the user's ability to navigate pre-defined timbre spaces (Vertegaal, 1996).This research inherited much from useability studies and general human computer interaction research (Wanderley and Orio, 2002, Mulder, 1996, Robson, 2002, Wessel, 1991b, Hunt and Kirk, 2000, Hunt et al., 2000).

We argue that not only has progress in the field been painfully slow, but it has not resulted in significant advances in instrument design or performer satisfaction. We contend that this is the result of a missed first step in evaluation of the performer's physical relationship with existing instrument models. Secondly, we feel that research effort has been misdirected by methods relevant in the areas of usability studies and human computer interaction. While these techniques provide coherent objective evidence, they are applicable to systems where ease of use, repeatability and generality of application are of the foremost importance. While musical instruments share some of these requirements, our priority lies in the area of musical expression.

Further Work

An extension to ThuMP is sought in an ARC Linkage application (TIEM) which seeks to develop a unified theory of practice for the application of new interfaces for real-time electronic music performance. The resulting taxonomy will be used to develop a design template that can be applied broadly in the development of new interface for electronic music performance. The IP for the design template will remain with the project. No methodology yet exists for the comparison of interactive music systems across performance, installation, and related contexts (Birnbaum et al., 2005). This project seeks to fulfil the following:

1. Review the range and types of realtime electronic music performance systems, the literature that describes those systems, and develop a Taxonomy of real-time Interfaces for Electronic Music performance (**TIEM)** which will be used as design guidelines for industry and have a flow on effect for artists, and the creative industries as a whole (a technologically sophisticated society (Florida, 2002).
2. Make explicit through **TIEM**, low-order system parameters (eg approaches to timbre control, modulation, density, amplitude etc) as well as higher-order interaction and multi-modal coupling of parameters (eg. relationships between pitch and timbre, modulation and intensity relationships, attack, pitch, timbre and amplitude envelop etc).
3. Apply **TIEM** as the basis of a theory of new realtime musical interfaces and, most importantly, make explicit the assumptions of that theory. Those assumptions will then be investigated using rigorous scientific methods to assess the validity or reality of, for example, the ordering or relations among parameters.
4. Investigating the psychological reality of the parameters used as the basis for **TIEM** from the point of view of the performer. Subsequent experimental work, some conducted in performance settings, will investigate the perceptual reality of the relations from the listener/audience perspective (Wessel, 1979b).
5. Apply the multi-layered taxonomical approach developed during **TIEM** as a template for designers in the field.

The **TIEM** project is located within existing research in performance interaction (Wanderley and Orio, 2002, Hunt and Kirk, 2000, Hunt et al., 2000, Rovan et al., 1997, Wanderley, 2001, Wanderley, 2002, Bradley et al., 2004, Chadabe, 2002b, Chadabe, 2002a, Dean, 2003) human-computer interaction (Alfred et al., 2004, Jeffery, 1999, Dean, 2003), design space analysis (Cook, 2001, Mulder, 1994, Mulder, 1996, Daniel et al., 2004), timbre space research (Wessel, 1979b, Grey, 1977, Kahrs, 1977) and musical instrument taxonomies (Kartomi, 1990). It applies cognitive psychological techniques to validation, preferencing the perspective of artistic imperative, rather than the technology that has been common in reporting on computer based electronic music performance systems to date. The **TIEM** project seeks to analyse the underlying system designs and gather qualitative responses from the performer, composer, as to the relationship between gestural and control events and the musical artefacts. **TIEM** moves beyond the technology to develop a nomenclature of approaches and outcomes on the basis of a classification of all gestural observation, artistic intent and empirical measurement. Video tracking systems (Optotrak and Peak Motus systems) at MARCS Auditory Laboratories (UWS) will be used to analyse the gestural relationships inherent in selected electronic music performances with experimental interfaces.

Conclusion

Both the **ThuMP** and **TIEM** projects provide a new methodology for the analysis of experimental interfaces for electronic music performance by developing a control→sonification model for successful acoustic instruments, and then applying this model as the foundation for the development of design guidelines for interfaces for realtime electronic music performance. The proposed taxonomy will provide an underlying foundation for future discussion and design of experimental musical interfaces, whilst simultaneously illustrating coherence within the research community that is currently absent. It is also worth noting that this project diverges from current practice by preferencing the perspective of artistic endeavour, rather than the technological imperative that has been common in computer based electronic music performance systems to date.

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